EXPERIMENTAL EVIDENCE FOR EFFECTS OF MAGNETIC FIELDS ON MOVING WATER

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Abstract - Observable changes of water by magnetic fields have been investigated in an attempt to contribute to the knowledge of the structure of liquid water. The crystallization mode of the water's mineral content was found to change from a dendritic, substrate-bound solidification habit to the form of separate disc-shaped crystals after the water had moved through a number of magnetic fields. The former scarcity of crystallization nucleii in the water had been turned into an abundance of nucleation centers in the water. The reduction of the number of the substrate-bound crystals has been used as a quantitative measure of the magnetic effect. A mechanism is suggested assuming that resonance between the time sequence of the magnetic fields and the internal vibratory frequency of the water complexes results in the fracture of some of the complexes. Thereby, the formerly encased foreign particles are released and provide the nucleii for the formation of the disc-shaped crystals throughout the volume of the water. Further studies are urged in view of the staggering potential benefits for many water uses, such as prevention of hard lime scale build-up, increased effectivity of chemical additions to water for softening, fertilizing, feeding, cleaning purposes.

INTRODUCTION

The world-wide controversy regarding the effects of magnetic fields on water results in part from the fact that surprizingly little is known about the physical structure of liquid water [1]. Many of the extra-ordinary properties of "ordinary" water are explained by the tendency of the water molecules to form complexes $(H_2O)_n$ with $20 \lessapprox n \lessapprox 200$.[2] Hydrogen bonds hold neighboring H_2O molecules together, forming clusters which cause the abnormal freezing habits of the water[3]. Internal vibratory motion accounts for the uniquely high specific heat of the liquid water[4]. The complexes form cage-like structures preferrably around ions and foreign particulate matter [5]. The hypothetical nature of the knowledge of the structure and the potentialities of liquid water became emparrassingly obvious by the scientific debacle concerning "Polywater" during the 1970s [6].

Reported observations of effects of magnetic fields on water have proliferated with the improvements of available permanent magnets, particularly in countries where chemical capabilities for water conditioning are less developed and therefore physical water conditioning is widely in use.[7]

Unprofessional claims of "magnetized water" or a "memory" of the water for magnetic fields have clouded the concept and abhorred scientists. It has been shown theoretically [8] that the interaction between magnetic fields and the hydrogen bonds between the water molecules are by orders of magnitude too weak for direct, significant effects.

It is the intent of this work to offer a tangible scientific concept whereby the influence of well controllable magnetic fields and a sensitive observation of crystallization modes may contribute to a more complete model of the structure of liquid water. As a by-product, some valuable and environmentally advantageous methods of water conditioning may emerge from these studies.

EXPERIMENTS

Waters with various mineral contents were forced to flow through a number of magnetic fields of permanent magnets. Systematic variations of the number of the fields, their sequences, field strength, and gradients, and of the water flow velocity were applied.

The water was placed on precleaned glass slides in quantities of 20, 50, and 100 microliters and allowed to evaporate. The development of the forming crystals of the mineral content of the water was observed microscopically in polarized light. Significant phases of the solidification processes were recorded photographically. Attention was focussed on the crystals of $CaCO_3$ which is the main component of the mineral content of most waters. The calcium carbonate crystals are particularly well identifyable in the polarized light because they are optically active and produce striking contrasts.

Each test slide carried at least one drop of water which had passed the equipment before the magnets were placed. This was for the direct comparison and in order to eliminate possible influences of the slide surface.

The micrographs show a part of the perimeter of a drop because almost all the solidification of the minerals takes place at or close to the outer rim of the drops. This is caused by a vigorous radial convection inside the evaporating drop which transports the heavier minerals towards the drop perimeter.

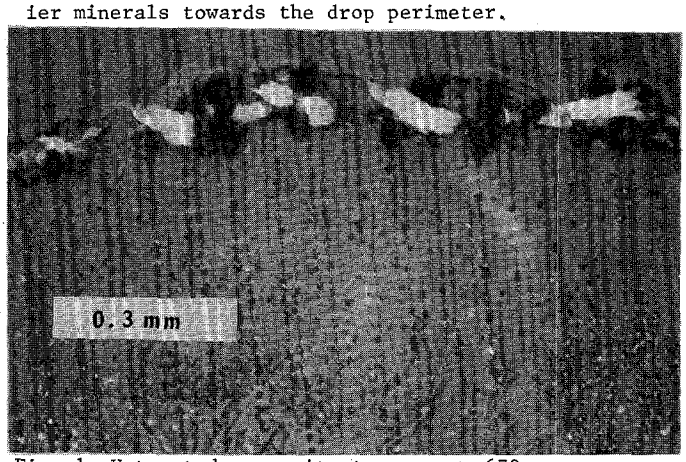

Fig. 1. Untreated community tap water, 670 parts per million total dissolved solids (PPM TDS).

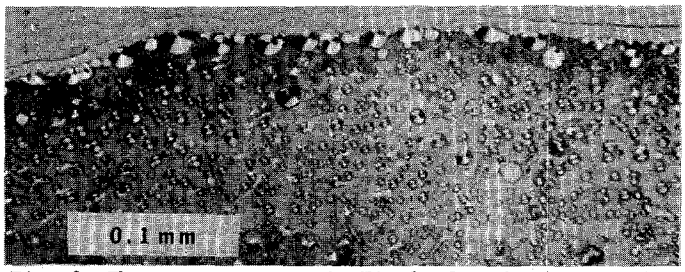

Fig. 2. The same water as in Fig.1 after having moved through 16 magnetic fields with nearly 100% effectivity.

50 microliters of tapwater with about 500 parts per million total dissolved solids (PPM TDS) typically evaporate leaving a ring of 500 prismatic crystals along its perimeter; a small amount of the minerals forms dendritic structures on the center of the drop.(Fig.1.)

If the same water had moved through magnetic fields it evaporates with some of its mineral content solidifying in the form of circular, disc-shaped crystals. (Fig.2) They may number in the millions, and their location is not confined to the perimeter even though the larger ones are found there. The prismatic crystals are less in number depending on the amount of minerals crystallized in the form of the disc-shaped, separate crystals.

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The effectivity E of the magnetic effect is defined by the reduction of the number of the prismatic crystals, determined by counting these crystals along the perimeters of the treated drop and substracting this number from the one of the untreated drop, expressed in percent.

The magnetic fields were provided by ferrite-type ringmagnets, magnetized axially and placed around the water conduit. A cylindrical bar of soft steel in the center of the water conduit assured the magnetic fields of up to 0.1 tesla to penetrate the entire water flow cross section.

Of major importance was the sequence of the polarity of the fields. Effectivities E above 80% were achieved with sequences of the type shown in Fig. 3. The effectivity increased decisively with the number of magnets increasing from 2 to 8.

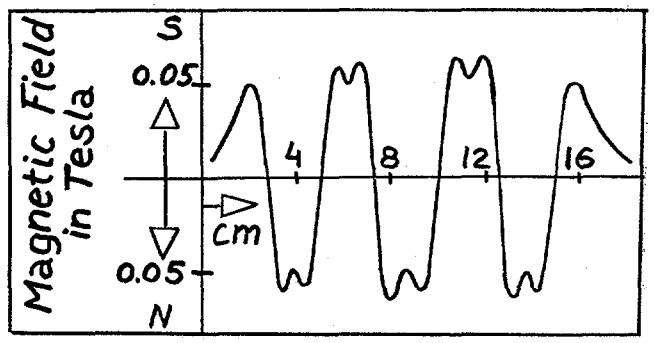

Fig. 3. Distribution of magnetic fields of 6 magnets along the water conduit resulting in effectivity curves as shown in Fig.4.

All effectivity values depended sharply on the velocity with which the water had moved through the field sequence. Fig. 4 shows two typical curves of the effectivity of the same magnet arrangement, but with different magnet spacings, plotted against the velocity of the water.

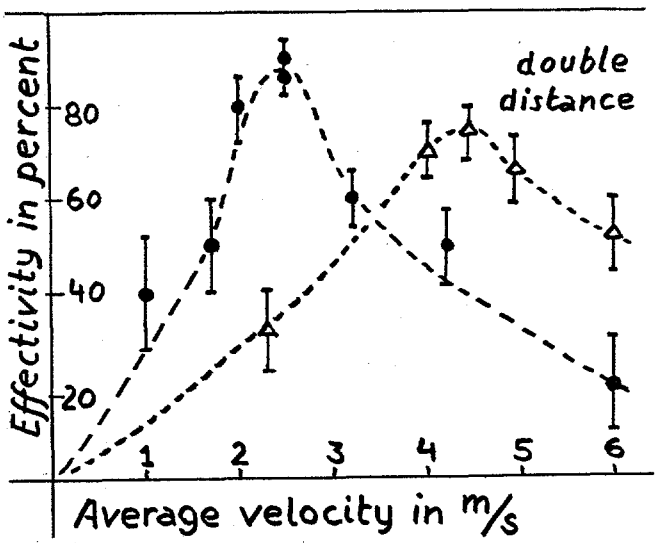

Fig. 4. The effectivity E vs. the average velocity of the water through magnetic field arrangements like in Fig.3, (I) and with twice the spacing between the magnets (II). The counting of the remaining "hard" crystals was more accurate for better effectivities as the error bars indicate.

Higher amounts of minerals as they are found often in water circuits of industrial equipment induce intense growth of dendritic crystallization spreading over large areas of the evaporated drop, as shown in Fig.5. All these crystals are firmly attached to the substrate; they represent the first phase of hard lime scale formation.

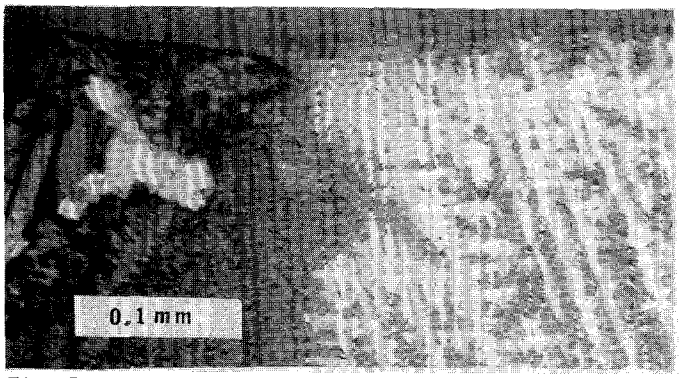

Fig. 5. Water of a solar heater circuit containing 1800 PPM TDS including iron salts; prismatic crystals and dendritic crystal growth prevail before magnets were installed.

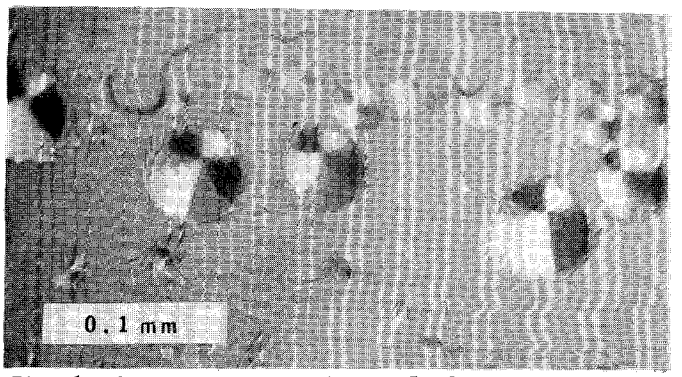

Fig. 6. The same water as in Fig.5 after installing a highly effective magnet system. The calcium carbonate crystallizes in circular discs with some secondary crystallization around their perimeters.

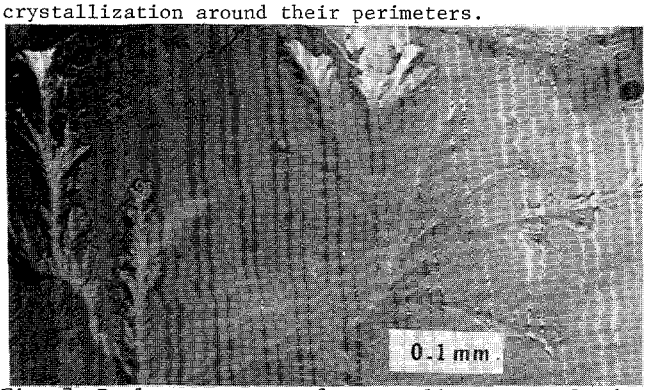

Fig. 7. Replacement water for a cooling tower of a hospital containing an organic algicide.

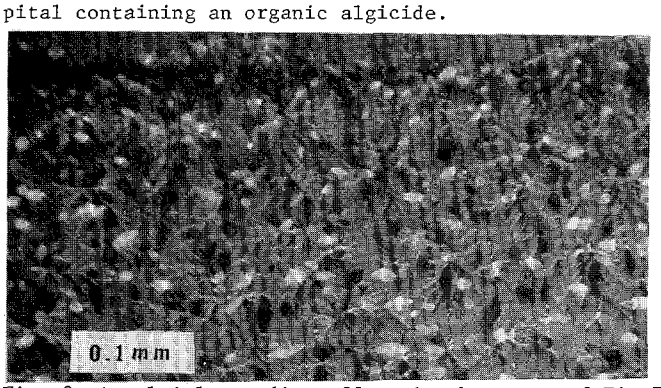

Fig. 8. A multiple seeding effect in the water of Fig.7 after repeatedly (about 25 times) passing through a magnetic treatment device.

CONCLUSIONS

Polarized light microscopy of evaporating water provides significant information about the modes of solidification of the water's mineral content. The main component, calcium carbonate appears in different shapes if the water has passed magnetic fields previous to the evaporation. Without the magnetic fields ordinary water is characterized by the scarcity of nucleation centers; super-saturation develops and accordingly the minerals start to solidify at the substrate in the form of dendritic crystallization. They grow to form thick, interconnected crystals and are firmly attached to the point where the nucleation started.

After passing magnetic fields, solidification nucleii in the volume of the water start the formation of separate, unattached crystals of calcium carbonate, mostly in the form of circular discs. 10^8 discs per cm^3 may contain the entire $CaCO_3$ content of a water with 500 PPM TDS. Assuming with Nemethy[2] that 50% of the water molecules are bound in complexes of about 200 molecules each, the active nucleation centers are released from their encaging complexes in sufficient numbers if one in 10^{13} complexes is fractured.

The dependency of the magnetic effects on a specific velocity of the water leads to the conclusion that the weak interaction between the magnetic fields and the hydrogen bonds is amplified to the breaking point by resonance. The magnetic treatment is usually most effective when the water passes through 12 fields in about 0.1 seconds. So, the frequency of the magnetic influences is of the order of 10^2 Hz. The frequency of the internal vibrations of a 200-molecule water complex held together by hydrogen bonds of 4×10^{-20}J (5) would be in the order of 10^4 Hz if the complex had a spherical shape. If it had the shape of a flat disc its frequency could be as low as 10^2 Hz. Further studies could help to determine more details of the complex-formation in liquid water.

Effective magnetic treatment results in a separation of formerly dissolved minerals from the liquid water by forming microcrystals which move with the water in suspension. The energy for this entropy reduction is provided by the kinetic energy of the moving water.

The liquid water is then depleted of its mineral content, and it is therefore able to dissolve minerals. The capability of magnetically treated water to redissolve old lime scale deposits is often observed and reported without a satisfactory explanation.

The internal seeding effect of the magnetic water treatment lasts for up to two days. The microscope observation reveals that the circular disc-shaped microcrystals of $CaCO_3$ deteriorate slowly by a solid state transformation into bundles of $CaCO_3$-needles called aragonite.

Other observations [7,9] of more subtle changes of the liquid water last only for a few minutes after the magnetic treatment. These changes are the reduction of surface tension and viscosity by up to 2 % and changes of the electro-optical values of the water. They are caused by the existence of fractured complexes before they recombine again to form the normal size complexes.

Many investigations are necessary for a quantitative model of these effects which have fare-reaching technical consequences.

SIGNIFICANCE

The lack of knowledge of liquid water is shocking in view of the importance of this mysterious substance for every branch of human activity. According to the late Felix Franks (1,6) more coordination between the different water-using disciplines would be of great value for all of them. Magnetic research could open up new avenues to this end.

It is difficult to maintain a scientific attitude in the face of the many pseudo-scientific enterprizes which try to exploit the tantalizing technical potential, which proliferate unfounded claims and give the magnetic water treatment a bad name.

On the other hand, unquestionable benefits have been reported, such as medical uses in China[10], agricultural improvements and desalination of soil [11], but mainly for the prevention of hard lime scale. We have quantitatively determined the effectivity E of a number of commercially available devices for magnetic water treatment. Most of them use the stray - fields of permanent magnets. In these devices only small amounts of water happen to hit a resonance between their complex-vibrations and the magnetic field sequence. Accordingly, they achieve effectivities E of only 10 to 50%. However, even the low effectivities lead to benefits like preventing lime scale if given sufficient time.

The more immediate effects of nearly 100% change in crystallization mode reported here are only observed with devices based on resonance. We have achieved the breaking loose of cm-thick lime scale deposits from the walls of old cooling towers which did not respond to the usual acid wash any more. Water circulation equipment has been kept free of any scale deposits for years with only a fraction of the chemical additions which would have been needed without the additional physical water treatment.

In general, magnetically treated water makes most chemical additions more effective. This is most noticeable for detergents (steamcleaners), fertilizers, feed stuffs, and softening agents. The wetting capability is improved for most powdery materials and surfaces. This shortens drying time when the water leaves a thinner film after running off surfaces. More subjective observations, such as diminished taste and smell from chlorine and sulfitic contaminations can be explained as a result of the secondary crystallization of these substances on the $CaCO_3$-seed crystals.

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